Development of a Smart LED Lighting System for Preventing Unconcentrated State

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ABSTRACT

In recent years, there have been many 'unconcentrated' students on the class such as 'inattention', 'reverie', and 'drowsy' state students. We especially focused on 'inattention' state in this research. This study developed a smart LED lighting system that improves declining concentrativeness of students by using eye-tracking device. Eleven volunteers participated in this study. As the results, the values of accuracy, sensitivity and specificity were 98.4%, 97%, and 99.5%, relatively. This proposed system can be utilized in the educational field soon.

1. INTRODUCTION

Improvement of student's ability to train academic performance at educational sites is a big issue. Recently, there are many students who do not concentrate on their classes due to the development of portable game controller (including smart phones). Therefore, we aim to develop a system to improve the concentrativeness of students in this research.

We classified the state of unconcentrated states into three categories: "Inattention (i.e. Wakimi) [1]", "Reverie", and "Drowsy [2]." A strike issue should be in an inattention state when many students usually watch something irrelevant to the class and attention decreases: shown in Fig. 1. Reverie is a state of abstracted musing; daydreaming. Drowsy is a state in which consciousness falls: sleeping and sitting unconsciously.

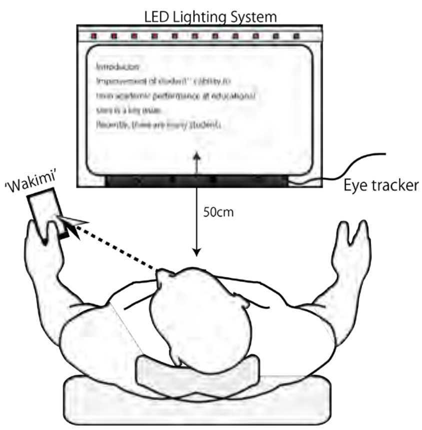

Fig. 1 The smart LED lighting system

These three states can be judged by measuring the line of sight. We aimed to develop a smart LED lighting system that improves declining concentrativeness of students by using eye-tracking device. In this study, we focused mostly on the state of "Wakimi".

2. METHODS

2.1 The smart LED lighting system

The proposed system consists of an eye-tracking device (Tobii eye tracker 4c, Tobii Technology Co., Ltd.), a self-made LED control box by using Arduino, and an LED light on the monitor. The Tobii eye-tracker 4c is a device that can perform eye tracking and head tracking at the same time. You can measure data on the line of sight, adjusting the offset depending on the position of the head. The eye is detected by using a near infrared beam (wavelength from 0.7 to 2.5 μm), as well as a method of reflecting light through the cornea. [3]. We setup the distance to 50 ~ 95 cm between the participant and the monitor. The operating frequency is 90Hz. In addition, we created the "Wakimi" detection program using the SDK of this equipment.

2.2 Experiments

Eleven participants (10 male and 1 female; 22.5±1.3 years) with normal vision were participated in this study. Participants asked to sit and monitor in front of the display. Calibration was performed prior to the experiment to adjust the difference in the position of the eyeball individual. To test the proposed system, we studied the reaction of the LEDs to the state of "wakimi" in accordance with the instruction (40 'Wakimi' epochs and 40 'Normal' epochs).

First, it is necessary to specify the region of interest for determining whether inattentive or not. The size of the monitor display is specified as attentive gaze region. Then, the proposed system finds the X and Y coordinate values of the line of sight of the participant. If the X and Y values did not exist within the range of interest and maintained this state for 5 seconds, system will judge this as 'Wakimi' and prompted the warning LED lamp to light up. The user also can arbitrarily set the time to judge as a 'Wakimi' stare. The color of the warning LED changes purple at normal to flickering-red at 'Wakimi'.

Table 1. Performance metrix in the System

Actual / Predict	Inattention	Attention
LED ON	TP (hit)	FP (false alarm)
LED OFF	FN (miss)	TN (correct negative)

2.3 Analysis

Critical Success Index (CSI) is one of the indicators to predict a certain event from the actual state and evaluate the predict performance of the system in binary categories [3]. The number of cases is shown in Table 1.

TP (True Positive) represents the number of cases where the system operated correctly when the participant remained in 'Wakimi' state. FN (False Negative) is missing and represents the number of cases that did not work when the participant was at 'Wakimi' state. FP (False Positive) is a false alarm, which represents the number of cases in which the system had excessively operated. TN (True Negative) represents the number of cases where the system does not operate properly when he/she should be at normal state.

Accuracy (agreement), sensitivity, and specificity are calculated as follows;

$$agreement = \frac{TP + TN}{all\,epochs} \times 100$$

$$sensitivity = \frac{TP}{TP + FN} \times 100$$

$$specificity = \frac{TN}{TN + FP} \times 100$$

The values of accuracy, sensitivity, specificity, and the Relative operating characteristic (ROC) curve were calculated from the evaluation experimental data using MATLAB.

3. RESULTS

Calculate accuracy, sensitivity, and specificity from the counts of TN, FN, TN and FP. The value of accuracy, sensitivity, and specificity were 98.4%, 97.0%, and 99.5%, respectively. The accuracy indicated that the system could be operated with a probability close to 100%. The sensitivity (hit rate) showed the verification that the warning from the system effectively urged participants that tried to stare at a smartphone to remain in concentrated state. The specificity could be said that the false alarm rate of the proposed system showed barely about 0.5%. The false alarm from system error is so very little that the proposed system does not break user's concentration.

We also derive the ROC curve as the probabilistic performance of the system as shown in Fig 2. The area under curve (AUC) value was 0.9873.

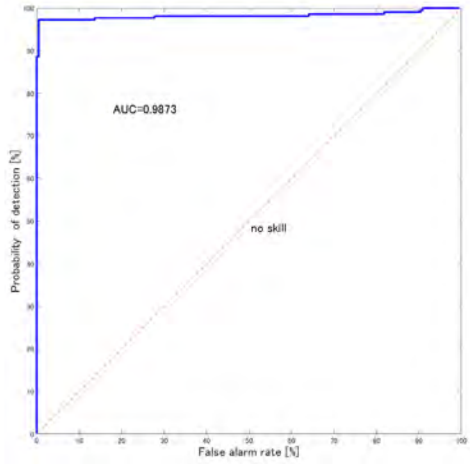

Fig. 2 Relative operating characteristic (ROC)

4. DISCUSION

In this research, we developed a focus concentration improvement from 'Wakimi' state. ROC curve measures the ability of the forecast to discriminate between hit rate and false alarm. The red-dotted line lie along the diagonal in Fig. 2 means that hit rates equal to the false alarm rates and the system, therefore, has no skill. The ROC of the proposed system was close to an ideal curve.

The Tobii eye-tracker did not wear on the body but was installed on the bottom corner of the monitor. Therefore, the physical burden on the user is reduced.

5. CONCLUSION

In this research, we developed a smart LED lighting system that improves declining concentrativeness of students by using the Tobii eye-tracking device. The results of eleven participants demonstrated that the proposed system could judge the 'Wakimi' state with a probability of 98.4%. Moreover, it can be said that the smart LED lighting system is a high-performance system close to the ideal state from the ROC curve. Therefore, this system can be utilized in the educational field soon.

6. REFERENCES

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